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THE AGRICULTURAL REVOLUTION IN THE UNITED STATES—1860-1930[1]

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THE transformations through which the United States has been passing since 1860 are so varied, so far-reaching and so profoundly significant that the historian is justified in assigning to this period of our history a place of importance second to none of the many corresponding epochs of time in the preceding centuries. It is an era of great complexity; a challenge to the student of American development.

The importance of these changes was emphasized more than a generation ago by David A. Wells in his book on "Recent Economic Changes" published in 1889 in which appear these significant passages:

The economic changes that have occurred during the last quarter of a century—or during the present generation of living men—have unquestionably been more important and varied than during any former corresponding period of the world's history. It would seem, indeed, as if the world, during all the years since the inception of civilization, has been working up on the line of equipment for industrial effort—inventing and perfecting tools and machinery, building workshops and factories, and devising instrumentalities for the easy intercommunication of persons and thoughts, and the cheap exchange of products and services; that this equipment having at last been made ready, the work of using it has, for the first time in our day and generation, fairly begun; and also that every community, under prior or existing conditions of use and consumption, is becoming saturated, as it were, with its results. As an immediate consequence the world has never seen anything comparable to the results of the recent system of transportation by land and water; never experienced in so short a time such an expansion of all that pertains to what

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is called "business"; and has never before been able to accomplish so much in the way of production with a given amount of labor in a given time.

The problems which our advancing civilization is forcing upon the attention of society are, accordingly, of the utmost urgency and importance, and are already occupying the thoughts, in a greater or less degree, of every intelligent person in all civilized countries. But, in order that there may be intelligent and comprehensive discussion of the situation, and more especially that there may be wise remedial legislation for any economic or social evils that may exist, it is requisite that there should be a clear and full recognition of what has happened.

Frederick J. Turner, who has inaugurated and inspired most of the work in the economic interpretation of history which has been done in this country, observed recently that:

> Few epochs in history have included such startling changes within a single generation as that between the eighties and the present. It is a hazardous task to attempt to portray the large outlines of a nation's changes and tendencies for the era of the present generation, especially an era of revolutionary changes in the material, political and social composition of a people. There have been generations of such stationary character that the historian's task in dealing with them is simple if not inspiring. But the very fact, that the generation which has passed . . . is one of such complexity and of such extraordinary change that it daunts the historian and almost forbids the attempt, is at the same time a challenge. For unless the American people turn at times from the rushing current of events to take observations, to look to the chart of their course, to measure their progress or decline, and survey its stages, they are not likely to comprehend the direction in which they are going, the meaning of the voyage, or the measures to pursue in the coming years. No one is wise enough, no one is far enough removed from the action, adequately to make this survey. The prepossessions and the prejudices, the survival of old conceptions, the complexity of the problems, are too great. It requires the base line which only coming generations can draw to measure the full meaning of these recent years and to reckon the things that should have been done and those that should have been undone.
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> Nevertheless a generation that does not attempt to consider its recent past is like the merchant who ignores his ledger, the mariner who takes no observations. However imperfect the results, it is necessary that the attitude of mind should be achieved. . . .

The dominant fact in American history during this period is the triple economic revolution which began its protean changes in England during the latter part of the eighteenth century and extended to the continent of Europe and the United States in the nineteenth century. Agriculture was transformed from a simple, pioneer and largely self-sufficing occupation into a modern business organized on a scientific, capitalistic and commercial basis; industry definitely underwent the change from hand labor in the home to machine production in the factory; and the local market was transformed into the world market. This threefold revolution in agriculture, industry and commerce is the key to the study of the recent history of the United States. While the antecedents of the economic revolution were already in evidence before 1860, it was the war between the states that hastened the tendencies and produced the changes that were destined to transform the economic and social structure of the nation and give rise to complex problems of reorganization and readjustment which to-day challenge the social sciences. With these observations in mind we may proceed to a consideration of the forces underlying the agricultural revolution in the United States.

I. THE PASSING OF THE PUBLIC LANDS INTO PRIVATE OWNERSHIP

The entire continental land area of the United States, excluding Alaska, amounts to 1,903,290,880 acres. The public domain comprised three fourths of this area, or 1,442,200,320 acres; while the remaining one fourth, consisting of the original thirteen states and the states of Kentucky, Tennessee and Texas, embraces an area of 461,090,560 acres which did not come under the control of the federal government and so was never a part of the public domain. Of this vast domain, the federal government had by 1860 disposed of 394,088,712 acres, thus leaving for future disposition an area amounting to 1,048,111,608 acres, the greater portion of which was located in the public land states west of the Mississippi River. The rapid disposal of the public lands dates from 1862 with the passage of the homestead act, the land grant college act and the act providing for a grant of land for the first transcontinental railroad. Under the provisions of the homestead law, the government during the period ending with June 30, 1929, disposed of 232,259,180 acres of land—an area equal to six times the area of Iowa. The preemption act of 1841, the timber culture act of 1873, the desert land act of 1877 and the timber and stone act of 1878, together with the right granted under the homestead law, enabled any person to acquire the title to 1,120 acres of land. Large areas of timber and mineral lands were acquired under other laws. The utilization of inferior lands was made possible by the Carey Act of 1894, the reclamation act of 1902 and subsequent legislation. The huge grants of land to states and corporations for the construction of railroads, wagon roads and canals, and for the advancement of education also facilitated the disposal of the public domain. The

establishment of forest and Indian reserves further reduced the amount of public land available for private entry.

This legislation made possible the rapid alienation of the public lands. The report of the commissioner of the General Land Office shows that in spite of the liberal policy of the federal government the remaining area of public land, unappropriated and unreserved, amounted on June 30, 1929, to 190,031,722 acres, located for the most part in the mountain and Pacific Coast states. The greater portion of this area, however, will never be available for agricultural purposes.

The transfer of this vast heritage from public to private ownership was accompanied by a corresponding increase in the farming area of the country. The number of farms was increased from 2,044,077 in 1860 to 4,008,907 in 1880. In 1900 there were 5,737,372 farms in the United States. This number was further increased to 6,448,343 in 1920. The number of acres in farms was increased from 407,212,538 acres in 1860 to 536,081,835 acres in 1880. This was further increased to 838,591,774 acres in 1900 and 955,883,715 acres in 1920. The average number of acres in farms was reduced from 199.2 acres in 1860 to 133.8 acres in 1880, due largely to the breaking up of the plantation system and the operation of the homestead law. This was increased to 146.2 acres in 1900 and 148.2 acres in 1920 but reduced to 145 acres in 1925; while the average number of acres of improved land in farms was reduced from 79.8 in 1860 to 71 in 1880 and then increased to 72.2 in 1900 and 78 in 1920. That is to say, the average size of farms and the average amount of improved land in farms remained fairly constant throughout the period.

The passing of the public lands has been accompanied by significant changes which characterize American agriculture in the twentieth century. Among these changes may be mentioned: (1) the rapid rise of land values and the consequent transition from extensive to intensive farming; (2) the growth of tenancy; (3) the decline of the agricultural export trade; (4) the utilization of the inferior lands, and (5) the reorganization of rural life. The passing of the public lands has brought agriculture to the crossroads with modern industry. This is perhaps the most distinctive phase of the agricultural revolution in the United States.

II. The Rapid Growth of Population and Immigration

The population of the United States, excluding the non-contiguous possessions, numbered 31,443,321 in 1860 and 62,947,714 in 1890. By 1920, it passed the one hundred million mark, reaching the number of 105,710,620. That is to say, population was doubled in thirty years and increased by three and a half times in sixty years. Immigration supplied 28,749,245. Of this number 10,373,628 arrived in the period 1860 to 1890, and 18,373,617 in the period 1890 to 1920.

The great abundance of good land and the liberal policy of the federal government in providing free homesteads for the settler attracted great numbers of immigrants from the Atlantic seaboard states into the farming states of the West. Hither came also large groups of European immigrants experienced in Old World methods of farming which they adapted to the requirements of a new frontier environment. They were as a rule industrious and thrifty, becoming a substantial part of the farming population and loyal American citizens. An agricultural empire was founded in the Mississippi Valley. Meanwhile, the Pacific Coast states were settled and added to this great imperial domain.

The population has until recently continued to be predominately rural. According to the United States census of 1880, the rural population (including towns and villages with less than 2,500 inhabitants) numbered 35,383,345, or 70.5 per cent. of the entire population. This was a number greater than the total population of the United States in 1860. In 1910 the rural population numbered 49,348,883, which was 53.7 per cent. of the entire population. The United States census of 1920 is the first to show that the majority of the American people now live in towns and cities: 48.1 per cent. being classified as rural, while 51.9 are classified as urban—the latter excluding towns and villages of less than 2,500 inhabitants, which are classified as rural. In 1910, 33.2 per cent. of all persons engaged in gainful occupations were engaged in farming—a greater proportion than was engaged in any other occupation. In 1920 the proportion of persons over ten years of age thus employed declined to 26.3 per cent., while the proportion of persons engaged in manufacturing and mechanical industries was increased to 30.8 per cent. This is a fact of fundamental significance in marking the emergence of the United States into an agrarian-industrial state.

These figures show that there has been a rapid increase in the rural population since 1790 and in the urban population since about 1880; but that while the rural population has been increasing, the urban population has been growing at a more rapid rate. That is to say, the rural population has entered upon a period of rapid relative decline, which is another way of saying that the population of the United States is becoming urbanized. Many students and writers have tended to lament the movement of population from the country to the city; to view with

misgivings the desertion of the farms and the concentration of population in crowded tenements; to urge the importance of checking this "trek to the cities," and even to propose a "back-to-the-land" movement. These views are opposed by those who urge that science, invention and power-driven machinery have made possible the migration of population from the country to the city; that this movement is inevitable; that it is destined to continue at an accelerated rate; and that it is really a natural process which is best for the nation as a whole.

Among those who hold this view may be mentioned the editor of *The Birmingham News,* who in a recent editorial made these significant observations:

> The forthcoming census is expected to show a greatly reduced population in the provinces and vastly larger urban increases in the last decade; for while those who quit the rural regions are coming to the congested centers, the great majority of immigrants also are drawn to centers where population is greatest. And despite the fact that the depleted rural population continues to supply sufficient food for the nation—largely because of intensive production aided by labor-saving machinery—sociologists still deplore the migration from country to town. Precisely why social students grieve over this movement is never stated very clearly. What is clear is that the reason for it is largely economic. What is plain as a pikestaff is that the foods, the wool, the cotton, the livestock of the future will be produced scientifically by trained farmers. What the tender-minded sociologist sees is the gradual tendency of American living to become complex. He deplores that families are moving in from the spacious acres, the green and fertile fields, away from the open air, to become industrial slaves—burdens to the labor market already glutted. But that is not altogether a fair picture. The question is whether an unskilled farmer, unable to wrest a living from sterile soil—since he lacks capital to fertilize it and brains to develop it—is worse off in the industrial centers where he must endeavor to wrest a living from the streams of trade.
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> Doubtless this will be a puzzle for students to worry over for many years ahead. So long, however, as the trained farmers of the nation can produce sufficient bread, meat and textiles to provide the non-producing workers in the so-called ''artificial industries,'' it must continue to be the paramount factor in that trek from the open spaces into towns where people rarely ever think of the processions of stars and suns. In times ahead when cities will become so greatly cluttered that the scientific farmers in the fields can not supply the demand for food, descendants of farmers who left the fields will go back.

Another view is expressed by Chester C. Maxey in his recently published book on "Urban Democracy." The writer observes that:

> The country is itself being urbanized. Automobiles, improved highways, telephones and radios are bringing the city to the country and the country to the city. A new chapter in country life is being written. The old distinctions between *rus* and *urbs* are gradually fading out. Agriculture is becoming a specialized industry, and the economic aspects of rural life are beginning to resemble those of the city. The truth is that city and country are alike caught in the same web of cosmic forces, and are doomed to share the same destiny. The outcome no man can foresee, but we know it will be shaped and determined by the ability of the human species to adapt itself to life in the great society which is being created by the urbanization of the modern world.

III. The Invention and Popularization of Improved Farm Implements and Machinery

"The year 1850 practically marks the close of the period in which the only farm implements and machinery other than the wagon, cart and cotton gin were those which for want of a better designation may be called implements of hand production. The old cast-iron plows were in use. Grass was mowed with a scythe, and grain was cut with the sickle or cradle and threshed with the flail." Although most of the epoch-making implements and machines which have revolutionized farming were invented and introduced into practical use before 1860, it was the Civil War decade that popularized these labor-saving devices. The withdrawal of hundreds of thousands of men from the farm to enlist in the army stimulated the use of such devices. The plow, the corn-planter, the two-horse cultivator, the mower, the reaper and the threshing machine rapidly overcame the conservatism of the farmer who, confronted with the alternative of losing his crops in the field for want of an adequate labor supply, now became convinced of the utility of these inventions when he saw it demonstrated, for example, that a reaper drawn by a team of horses and operated by one man could cut from ten to twelve acres of an ordinary stand of wheat in a day, whereas a man with a grain cradle could by laborious effort cut but an acre and a half to two acres of wheat in the same length of time.

Many notable mechanical improvements have been introduced and widely adopted since that time. The list is legion. The more recent introduction of power-driven machinery utilizing gas and electricity is a significant feature of this development. The question whether the horse or the tractor affords the most economical power for farm use is the subject of a lively controversy which must be decided by the farmers themselves with reference to their individual circumstances. The use of improved farm implements and machines has not only added greatly to the productivity of each unit of land and of labor but it has also made possible the intensive cultivation of a larger area of land. The topography of considerable areas of the

arable land of this country is comparatively level, which favors the use of farm machinery on a larger farm unit basis. The tendency of farmers to specialize in a few staple crops adds still further to the advantages of machinery, while the relatively large size of American farms makes the use of machinery economical. It is therefore apparent that while the size of farms varies, depending on the type of farming carried on, a farm "ought to be large enough to occupy the reasonable working time of the farmer and his family when they use the best and most efficient tools and machinery known to the farming world, with ample horse power, or some other form of power to drive that machinery." The tendency in the United States has been to reduce as much of the farm work as possible to mechanical process. This is one of the most significant aspects of the revolution in American agriculture.

IV. The Extension and Development of Transportation Facilities

The history of the United States from the beginning of colonization is in a very real sense the history of the development of transportation and communication. Prior to 1850, the principal avenues for the disposal of farm products were the two great waterways of the country: (1) the Mississippi River with its navigable tributaries, and (2) the Great Lakes with their eastern connections, the Erie Canal and the Hudson River and the Welland Canal and the St. Lawrence River. The early railroads in the Middle West were regarded as tributaries of the waterways; but the rapid extension and improvement of railway facilities after 1850 was destined to effect profound changes in both agriculture and industry and to revolutionize the whole course of internal trade. In 1860 there were 30,626 miles of railroad in operation, distributed equally among the three great sections of the country: the East, the South and the West. The rate of construction was checked somewhat during the war between the states, but immediately after the war the entire country was seized with a mania for railroads. In 1870 there were 52,922 miles in operation. This was further expanded to 93,922 miles in 1880 and 166,654 miles in 1890, finally reaching 198,904 miles at the close of the century. Railway expansion continued, amounting in 1910 to 249,992 miles and in 1916 to 254,251 miles. Since that date there has been a continuous annual decrease of railway mileage, which in 1927 amounted to 249,131 miles. The country was spanned with a network of railroads. Chicago became the greatest railway center in the world, with St. Louis as a keen competitor for first place. Five transcontinental railroads were constructed, thus bringing the Pacific Coast states into direct economic relationships with the Mississippi Valley and the Atlantic seaboard states.

No less important than the rapid growth of mileage were the great improvements which accompanied the development of rail transportation. Reference should be made especially to the reduction of grades and curves, improved drainage and ballasting, better bridges, the introduction of steel rails, the increase in the capacity of freight cars and in the drawing power of locomotives, the adoption of uniform gauges, the establishment of belts of standard time, the development of terminal facilities, including side tracks, warehouses and terminal elevators, and scientific rate-making.

These improvements, supplemented by the advantages afforded by rapid transit and reduced risks, tended to increase the value of railroads as commercial highways which by the middle of the seventies had become effective competitors of the waterways in the transportation of farm products. The introduction of the iron steamship on the ocean after 1860 and the formation of combinations between railroad and steamship lines, which made possible the shipment of products on through bills of lading from interior points to the markets of Europe, further increased the importance of the railroads as carriers of farm products. These developments were further accompanied by improvements in the facilities for communication which served to bring all sections of the country and the nations of western Europe into more interdependent relationships. Of these, the telegraph was the most important agency for the rapid dissemination of information without which the organization and management of the modern commercial system would have been impossible. The improvement of the postal system, the growth of newspapers and trade journals, the invention and extension of the telephone system, the organization of produce exchanges and the modern system of banking and rural credit facilities also performed incalculable services in transforming agriculture from the self-sufficing into the commercial stage.

The extension and development of transportation facilities, rapid though it has been, has not kept pace with the surplus production of farm and factory. The inadequacy of the present system for the handling of this surplus, combined with high freight rates, has led to the urgent demand since Roosevelt's administration for the improvement of our great inland waterway system. This includes two great projects of importance to the Middle West: the restoration of the upper Mississippi River to its former importance as a carrier of bulky products such as grain and lumber and also coal and machinery; and the development of the Great Lakes-St. Lawrence waterway. These

projects are opposed by the commercial interests of the East, which foresee in the construction of this route and the consequent development of great seaports in the American Mediterranean the destruction of a monopoly of the western traffic in grain and livestock products which it has held since the completion of the Erie Canal.

The twentieth century marks the beginning of a new epoch in the history of transportation. The new heralds of progress are the automobile and the airplane. In 1900 there were 8,000 automobiles in the United States. Had any one then predicted a million automobiles within a generation he would have been ridiculed for his child-like fancy; but in how short a time would his prophecy have been redeemed? There are now 25,000,000 automobiles in the country: one to every four of the population! What a great influence this fact has had on the good roads movement and on rural civilization! There are now about 8,000 commercial airplanes in use in the United States, which is equal to the number of automobiles in 1900. Aviation is indeed on the threshold of a new era of remarkable development. The Curtiss Airport Corporation has definitely inaugurated a program of constructing twenty-five or thirty airports in this country and the island possessions, each airport costing from $2,500,000 to $3,000,000. Who can doubt the tremendous possibilities of commercial aviation and its importance as a factor in reconstructing rural life?

V. The Migration of Industries from the Farm to the Factory

The distinguishing feature of farm life in the pioneer period was its economic self-sufficiency. There was no market for farm products; consequently no goods could be purchased from the outside. Each farm was "an economic microcosm," producing for itself practically everything that it consumed: food, clothing, furniture, linens, soap, candles and a great variety of minor articles essential to the farmer and his family. The transfer of these industries from the farm to the factory is the most significant aspect of the transition from self-sufficient to commercial agriculture. It is an interlocking feature of both the agricultural and industrial revolutions. This is emphasized by the fact that the farms furnish approximately three fourths of the raw materials of industry, while fully one half of the products sold by the farmer are purchased by our manufacturing plants. The transformation of farm products by industrial processes into goods ready for the consumer is therefore the basic fact in the transition from pioneer self-sufficiency to commercial agriculture and industry.

The migration of industries from the farm to the factory since 1860 is characterized by the evolution of technical processes of manufacturing, increased market demands due to the growth of population, the addition of many new products and the utilization of by-products, new methods of marketing, improved methods of factory organization and management, concentration of manufacturing into large establishments and the localization of industries at advantageous points. These forces made possible increasing specialization which characterizes the transition from self-sufficient to commercial agriculture.

The industries that have been transferred from the farm to the factory may be classified into three groups: (1) food products; (2) textiles and clothing, including boots and shoes; and (3) tobacco and a number of minor products. The food industries include slaughtering and meat packing, flour milling, the manufacturing of dairy products, the canning of fruits and vegetables, the preparation of poultry and its products and the production of preserves and pickles. Many new industries have been added, such as the manufacture of beet sugar and the production of bread, pastries and confections. The list of package products includes a considerable number of animal and vegetable products. In 1860 flour and grist mills ranked first among the manufacturing industries in valuation of products, which amounted to $248,580,000. In 1919 slaughtering and meat packing ranked first with a total output valued at $4,246,290,000, while iron and steel ranked second in products, valued at $2,828,902,000, and automobiles ranked third with a valuation of $2,387,903,000. The products of all food industries were valued at $12,438,891,000, which was 20 per cent. of the total value of manufactured products in the United States.

The transfer of the textile and clothing and the boot and shoe industries from the farm to the factory has been studied chiefly from the standpoint of the development of manufacturing in the United States, but it deserves the attention of students of the history of American agriculture. It has been estimated that the household production of textiles in 1820 constituted more than two thirds of the entire product. The age of homespun gave way to the factory system by the operation of the same forces that took the food industries out of the home and placed them in the factory. In 1919 the total value of manufactures of textiles and their products amounted to $9,216,103,000.

The significance of the transfer of these industries from the farm to the factory can hardly be exaggerated. It is "the best evidence of the extent and rapidity of the transition from self-sufficient to commercial agriculture."

VI. THE EXPANSION OF DOMESTIC AND FOREIGN MARKETS

These forces made possible a territorial division of labor which enabled each section to devote itself more exclusively to the production of those commodities for which it was best adapted: the East to manufacfacturing and commerce; the South to the raising of cotton, cane and tobacco, and the West to the production of grain and live stock. That is to say, there were created three great economically interdependent sections bound together by reciprocal trading interests. The East became the home market for the surplus products of the West and the South, taking grain and flour and meat for its rapidly growing urban population and raw materials for its factories and offering in return the products of its factories.

The volume of production, however, exceeded the demands of the home market, thus giving rise to an annual product far in excess of the needs of the country, but for which there fortunately existed a growing demand abroad. The development and expansion of the facilities for the transportation and handling of bulky products and the reduction of freight rates transformed the local into the world market, the effect of which was twofold: first, it stimulated the production of food in the great agricultural regions which now had access to the markets of the world; and, second, it subjected the agricultural systems of the western European countries to a severe strain of competition which compelled large numbers of the rural population to abandon farming. As a result, they either migrated to the industrial centers to enlist in the army of wage-earners or emigrated to the New World, the greater proportion of them settling in the United States, which furnished unequaled opportunities for the making of an independent living. The countries of Europe thus became the natural market for the breadstuffs and live-stock products and the cotton and tobacco which entered into the export trade of the United States. The most important market for these commodities was Great Britain, which after the repeal of the Corn Laws in 1846 was transformed from an agricultural into an industrial nation largely dependent on foreign nations for an adequate supply of foodstuffs and raw materials. The nations of continental Europe were second in order of dependence, while the non-European countries of South America, the West Indies, Canada, China, Australia and South Africa came next. These countries all furnished markets that absorbed the surplus agricultural products which the United States had available for export. Meanwhile Russia, India, Australia, Canada and Argentina became strong competitors of the United States for this trade.

The principal items entering into agricultural export trade of the United States during the period under review were grain and flour, live-stock products, cotton and tobacco. The rapid expansion in the volume of these exports during the latter part of the nineteenth century was followed by a marked decline during a period of approximately fifteen years preceding the outbreak of the World War. Grain and flour and live-stock products declined at a precipitous rate, while cotton and tobacco continued at a fairly steady rate. The forces contributing to the sharp reduction in grain and meat exports were: (1) the tariff policies of France and Germany; (2) the competition of Argentina, Canada and Russia; and (3) the growth of the home market. These forces are of a permanent character, thus pointing to the day when the United States will cease to be a food-exporting nation.

The present agricultural situation in the United States is due in no small measure to the fact that Europe during the last decade has been unable to absorb its normal share of our exportable surplus. This condition will probably not be remedied until European nations have recovered their prewar purchasing power and world markets have again become stabilized. Domestic legislation may provide temporary relief; but it will not solve the problem. The farmer is dependent on foreign markets for the disposal of 60 per cent. of his cotton, 20 per cent. of his wheat and 15 per cent. of his pork and lard. He is dependent on Europe for the absorption of 80 per cent. of his whole exportable surplus. But the reduced purchasing power of Europe is a factor of more or less permanence. Moreover, Europe has been going back to the farm, with the result that it is to-day really less dependent on American food products than in the prewar period. But let us suppose that the European countries recover their former purchasing power. The United States has come to the end of the free land epoch and entered the period of high-priced land and high cost of production while Canada, Australia, New Zealand, South Africa, Argentina and Russia, with low-priced land and low cost of production, have become competitors of the United States in the markets of the world for the disposal of their surplus food products. The advantages lie with the new countries.

The present insecurity of the farmer in the foreign market of the world is therefore more or less permanent. There is but one alternative which offers any hope of escape from this condition. This alternative is the reorganization of American agriculture to meet the demand of a rapidly expanding home market. This means that the time has come when less attention should be given to the production of the great world

agricultural staples such as wheat, pork and cotton and more attention to the production of perishable and semi-perishable commodities—dairy products, vegetables, fruits and the like. But even so, it will be some time before we cease to be a food- and cotton-exporting nation, for the reorganization of agriculture along the lines suggested can not be effected in less than a generation for reasons which are inherent in the nature of the farming business.

VII. The Establishment of Agencies for the Promotion of Scientific Knowledge Relating to Agriculture

Interest in scientific farming dates back to the beginning of the national period of our history, but this interest was shared by but a comparatively small number of progressive farmers. The great mass of the rural population followed the rule of tradition, custom and superstition which prevailed throughout the pioneer period. The reluctance to apply scientific principles to the practice of farming is explained by the fact that it was easier and more economical to acquire and cultivate new land than to institute intensive methods on the older land. Moreover, the farmers generally possessed a very meager knowledge respecting the proper treatment of soils and plant life, even the most intelligent farmers, including the scientists themselves, knowing very little about such matters. Then, too, the great majority of farmers were averse to new ideas and methods which they regarded as "book farming" and therefore as impracticable. This attitude is due largely to the fact that the farmers of the pioneer period, accustomed to a life of isolation and separation from their fellowmen, were naturally independent and extremely individualistic, relying on their own initiative and taking pride in following their own peculiar methods of farming, when it would have been easier and less expensive for them to seek and follow the advice and experience of others.

The rapid disposal of the public domain after 1862 soon brought the nation to the end of the free land era when rising land values made it necessary for the farmer to change from extensive to intensive methods; and the transformation of agriculture from the pioneer into the commercial stage brought the farmer into closer relations with the business world. The new conditions thus created broadened the farmer's outlook and awakened him to a realization of his educational needs and opportunities. This period also witnessed the rise of a new generation of farmers who were ready to abandon primitive methods of farming and adopt scientific methods as soon as their utility was demonstrated. Agriculture, thus liberated from the fetters of custom and tradition, was prepared to enter upon a new era of development. This led to the creation of agencies for the promotion of scientific knowledge relating to agriculture. The limits of this paper will permit only a brief consideration of these agencies in the education of the farmer along scientific and practical lines.

The Federal Government first took an active interest in the promotion of agriculture in 1839, when, on the recommendation of the commissioner of patents, an appropriation of $1,000 was made for the "collection of agricultural statistics, investigations for promoting agriculture and rural economy, and the procurement of cuttings and seeds for gratuitous distribution among the farmers." The work was gradually developed by the Patent Office, through its agricultural division, until 1862, when the Department of Agriculture was established. The functions of this department as defined by law were "to acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word, and to acquire, propagate, and distribute among the people new and valuable seeds and plants."

This department grew slowly at first, owing to inadequate moral and financial support; but as the need for a scientific knowledge relating to agriculture developed, the functions of this department were gradually expanded. By 1889 it had finally achieved sufficient dignity to be raised to the rank of a cabinet office. Thereafter the work of the department was rapidly developed until it became the leading government agency of its kind in the world for the promotion of scientific research relating to all lines of agricultural development, including plant and animal life, crop production, insect pests, trade and commerce, irrigation, statistics, quarantine and road-making—almost everything, indeed, affecting the interests of those engaged in the raising and marketing of agricultural products. In 1927 the total expenditures of the department amounted to $153,049,018.

The U. S. Department of Agriculture is supplemented by the state departments, most of which have been established since 1860. The functions of these may be defined in general terms as follows: the collection, publication and distribution of crop statistics; the holding of state and district fairs; the conducting of farmers' institutes; the enforcement of laws relating to live stock and human foods; the control of insect pests and fungus diseases in orchards, nurseries and vineyards; the enforcement of quarantine laws against animal diseases; the operation of experimental farms; the distribution of seeds and plants, and the preparation and publication of annual reports, journals and bulletins.

The same year in which the U. S. Department of Agriculture was established marks also the passage

of the land-grant college act, providing for the establishment of colleges of agriculture and mechanic arts. According to the provisions of this law, each state received 30,000 acres of public land for each representative and senator to whom the state was entitled in Congress under the apportionment of 1860. The interest on the money derived from the sale of this land was to be appropriated for "the endowment, support, and maintenance of at least one college where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

The land-grant act of 1862 was the most important specific enactment ever made for the promotion of scientific knowledge relating to agriculture in the United States. It gave a great stimulus to the movement, already inaugurated before 1860, for the establishment of state-supported institutions of learning devoted to "the liberal and practical education of the industrial classes." Many states accepted the conditions of the grant soon after the passage of the act. There are now sixty-nine institutions in the United States receiving the benefits of this grant.

The land-grant colleges underwent a period of slow development during the first twenty-five years of their existence. It was a period of organization and of discussion as to what the character of these institutions should be in order to fulfil the purpose of the act and to meet the needs of "the industrial classes" in the respective states. Courses in the study of the sciences were yet to be developed, teachers in these subjects were to be trained and the system of elective studies was to be organized, while graduate courses of instruction and research remained to be developed later. It was therefore impossible to develop technical courses in agriculture until the sciences were placed on a sound basis with adequate equipment and well-trained teachers in charge of these courses. The most important functions of the land-grant colleges during this period were, therefore, first, the establishment and perfection of instruction in the natural sciences; and, second, the development of technical courses suited to the needs of farmers and mechanics. At the same time, they gave instruction in a variety of general subjects, thus developing a broader view of what constitutes a liberal education. Finally, they rendered a valuable service in preparing teachers and scientists who later rose to eminence in the work of technical instruction as well as in scientific and practical investigations.

The natural outgrowth of this development was the experiment station. The first regularly organized experiment station in the United States was established by the state of Connecticut in 1875. Other states followed until by 1887 there were seventeen stations in operation in fourteen states. In that year, Congress passed the Hatch Act providing for the establishment and maintenance of experiment stations as departments of the land-grant colleges in all the states and territories. The experiment station thus became an integral part of the agricultural college, while its work has formed the basis of all instruction relating to the science of agriculture. In addition to this, it has performed a valuable service in the publication and dissemination of bulletins on a variety of subjects of great interest and importance to the farmer.

By 1890, the land-grant colleges were beginning to achieve a place of influence and prestige among the better colleges and universities of the country. Since that year these institutions have undergone a rapid growth and development along three clearly defined lines: first, teaching; second, research and experimental work, and, third, extension work. The development of this threefold function has made the land-grant college, in cooperation with the U. S. Department of Agriculture, an important factor in the transformation of farming from a pioneer occupation into a modern business organized on a scientific basis.

The rise and growth of farmers' organizations should also be mentioned as one of the important agencies for the diffusion of knowledge relating to the practice of farming. The revolution in agriculture gave rise to complex problems of production, distribution and exchange which were of fundamental interest and importance to the farmers. As agriculture became more interwoven with the fabric of our national economy, these problems became more and more acute. It was therefore natural that the farmers should follow the example of other economic groups and organize for the promotion of their interests. This period, consequently, witnessed the formation of many organizations which may be divided into two general groups: first, those serving some special end or industry, as, for example, the cooperative creamery associations and the farmers' elevator companies; and second, those which sought to unite the farmers as a class, among which organizations may be mentioned the Granger, Greenback, Farmers' Alliance, Populist and Farm Bureau movements. These various organizations—local, state and national—performed a great service in the education of the American farmer. They aided in breaking down the barriers which had heretofore separated the farmers from their

fellowmen, developed in the farming population a feeling of class consciousness, taught valuable lessons in cooperation and became an important agency for the dissemination of the new ideas and methods in farming which were being advanced by the agricultural colleges and experiment stations.

Of inestimable importance, finally, as an agency for the promotion of scientific knowledge relating to agriculture was the agricultural press. It would be difficult, indeed, to estimate the influence of the agricultural press on the development of scientific farming in the United States. From the beginning it has dealt with an infinite variety of subjects; it has been one of the most efficient agencies for the popularization of the results of scientific experiments conducted by the agricultural colleges and experiment stations, and it has accorded much space in its advertising columns to ways and methods of improving the practice of farming.

The significant aspects of the agricultural revolution in the United States may now be stated: (1) the passing of the public lands into private ownership; (2) the rapid growth of population and immigration; (3) the invention and popularization of improved farm implements and machinery; (4) the extension and development of transportation and communication; (5) the migration of industries from the farm to the factory; (6) the expansion of domestic and foreign markets; and (7) the establishment of agencies for the promotion of scientific knowledge relating to agriculture, among which may be mentioned, especially, the federal and state departments of agriculture, the agricultural colleges and experiment stations, including rural extension work, the farmers' organizations, with their economic, social, educational and political functions, and the farm press. These forces transformed farming from a pioneer and largely self-sufficing occupation into a modern business organized on a scientific, capitalistic and commercial basis. Farming became inextricably bound up with the business world. It had become indeed the warp, with industry as the woof, of our national economy. These new developments and relationships gave rise to many problems which to-day confront the nation and which require for their solution a thorough scientific knowledge of farming and a sound, far-sighted and well-balanced statesmanship.

The agricultural situation in the United States during the last decade has produced a large volume of discussion of the farm problem. "In considering this discussion," observes Dr. C. L. Holmes, "one is struck by the fact that almost all of it has been from the point of view of the immediate situation, and (that) but little has been said of the long-time aspects of the problem." Dr. Holmes then proceeds to state the long-time aspect of the problem in the following terms:

> An analysis of the present agricultural situation, and causes which have operated and are still operating to bring it about, seems to justify the conclusions: first, that the present depressed condition of our agriculture is due primarily to certain more or less permanent results of the World War, first, in the direction of expanding our agricultural output and, second, of impairing our foreign market for agricultural products and of redirecting the currents and changing the content of our international trade; second, that the recovery of our agricultural industry depends upon the adjustment of our agricultural production, both qualitatively and quantitatively, to the domestic market; and third, that the result of these necessary adjustments will be the beginning of a new era in American farming, representing as profound a change as that which came with the shift from self-sufficing to commercial agriculture.

Dr. Holmes adds, however, that this "does not point to a policy of inactivity and indifference. The emergency truly is great enough to demand the best thought and effort of our agricultural leadership. Probably no previous period has presented so great a need as the present for the best effort of educators, legislators and the leaders of the farmers' movement toward making general an intelligent view of the real nature of the situation, toward making as easy as possible the adjustment to the new alignment of forces, and toward developing unity of purpose and concerted action on the part of the agricultural class. There was never so great a need, and probably never so great an opportunity, for the development of a comprehensive and far-reaching agricultural policy."

OBITUARY

MEMORIALS

THE unveiling of a bronze memorial tablet of Dr. William Royal Stokes in the municipal building, Baltimore, took place on November 26. Dr. C. Hampson Jones, commissioner of health, presented the tablet and addresses were made by Dr. William H. Welch, professor of the history of medicine in the Johns Hopkins School of Medicine, and Dr. Hugh S. Cumming, surgeon-general, U. S. Public Health Service. The tablet bears the relief portrait of Dr. Stokes and underneath the inscription: "To the memory of an able physician and bacteriologist. A lover of art, music and poetry, who died a martyr to the cause of science, contracting psittacosis (parrot fever) in line of duty."

Under this is the inscription: "Erected by his fellow-employees of the Baltimore City Health Department, 1930."

IN the presence of relatives and friends, among whom were members of the faculty and many former students, a portrait of the late Dr. Henry P. Talbot, dean of students from 1921 to 1927, was recently shown for the first time in the office of Dean H. E. Lobdell, at the Massachusetts Institute of Technology. Dr. Talbot, whose death occurred in 1927, was a professor in the department of chemistry at Technology from 1892 to 1927, and he was head of the department from 1901 until 1922. The portrait was painted by E. Pollak-Ottendorff, of Boston. It is a gift to the institute from a group of former students, and its title plate bears this legend: "As alumnus, teacher, and administrator for forty years, he gave conscientiously and unselfishly of his brain and heart to the upbuilding of the institute."

AT the annual meeting of the Michigan Section of the American Institute of Chemical Engineers, held at Ann Arbor on November 11, the following memorial to Herbert H. Dow, founder of the Dow Chemical Co., was adopted: "The death of a leader brings to our minds a feeling of pride over his achievements as well as grief at our loss. It is with these mingled feelings that we pay tribute to the memory of Herbert H. Dow, recognized the world over as a brilliant leader in the field of chemical manufacture, but known to us also as a sincere and helpful associate and friend, willing to give freely from his store of knowledge and experience. We extend our deep sympathy to the family, and to those who labored so intimately with him in the great plant which will stand as a monument, not of dead stone, but of living service continuing as it did in his life time."

THE College of Physicians of Philadelphia held a meeting on October 23 to commemorate the anniversary of the birth of Galen, called the founder of experimental physiology. Ninety-three of the ninety-eight Galen publications, the property of the college library, were on exhibition. The meeting was addressed by Drs. William H. Welch, Charles W. Burr, Burton Chance and Giuseppe Franchini, of Bologna, Italy.

PROFESSOR ALBERT EINSTEIN made an address before the Prussian Academy of Sciences on November 26, in commemoration of the three hundredth anniversary of the death of Johann Kepler.

RECENT DEATHS

JAMES H. EMERTON, an authority on spiders, illustrator of scientific books and constructor of zoological and anatomical models, died on December 5 in his eighty-fourth year. From 1906 to 1919 Mr. Emerton was secretary of the New England Federation of Natural History Societies. He was a brother of Professor Ephraim Emerton, of Harvard University.

WILLIAM PENN RICH, botanist, for twenty-one years secretary and librarian of the Massachusetts Horticultural Society, died on November 30, at the age of eighty-one years.

PROFESSOR ALFRED ELY DAY, professor emeritus of natural sciences at the American University of Beirut, Syria, died on December 3.

DR. ERNEST ELLSWORTH SMITH, a specialist in experimental medicine and clinical pathology and president of the Medical Association of Greater New York, died on December 5 at the age of sixty-two years.

THOMAS G. GERDINE, engineer in charge of the Pacific division of the U. S. Geological Survey, with headquarters in Sacramento, has died at the age of fifty-eight years.

HEINRICH GUSTAV ADOLF ENGLER, long professor of botany at the University of Berlin and director of the botanical garden and museum, died on October 10, at the age of eighty-six years.

THE death is announced of Dr. Rudolf Disselhorst, professor of comparative anatomy at the University of Halle.

SCIENTIFIC EVENTS

THE LIBRARY OF THE DEPARTMENT OF AGRICULTURE

INCREASED appropriations made possible the addition of 16,563 books, pamphlets and maps to the Library of the U. S. Department of Agriculture in the fiscal year 1929, according to the annual report to Secretary of Agriculture Hyde, of Miss Claribel R. Barnett, librarian. This was 2,209 more than the number added the previous year. On June 30 the library contained 218,038 volumes on agricultural and scientific subjects and was receiving 4,080 periodicals. It receives 128 daily newspapers. More than 268,000 books and periodicals were circulated in this period. In addition to the main library, branch libraries are maintained in the various bureaus of the Department of Agriculture, dealing with the subjects of special interest to these bureaus.

In cooperation with the land-grant college and ex-

periment-station libraries, the library issues a mimeographed publication, Agricultural Library Notes. Under a cooperative arrangement between the department and the editors of *Biological Abstracts*, the latter has opened a branch office in Washington and has been assigned office space in the main library. An increase of $5,000 in the library appropriation was also secured to make possible an increase in the library accessions in the field of biology. Dr. F. V. Rand, who is in charge of the Washington office of *Biological Abstracts*, reports that as a result of this cooperation, about 850 serial publications which have not hitherto been available are now being covered in the abstracting work. Other cooperative bibliographical projects are being carried on by the branch libraries, particularly with institutions and associations. The library of the Bureau of Agricultural Economics is cooperating with the Bureau of International Research and the American Country Life Association; the library of the Bureau of Entomology with the Association of American Economic Entomologists; the library of the Forest Service with the National Research Council; the library of the Bureau of Plant Industry with the Wild Flower Preservation Society, and the library of the Bureau of Public Roads with the American Association of State Highway Officials.

In cooperation with the division of bee culture investigations, a list of publications on apiculture contained in the library has been issued as No. 21 in the series of "Bibliographical Contributions" of the library. The bibliography on rural standards of living, prepared in the library of the Bureau of Agricultural Economics the past year, was published recently. The fourth Index to the Literature of American Economic Entomology, covering the years 1925–1929, prepared by the librarian of the Bureau of Entomology, is now in press.

BLIGHT RESISTANT CHESTNUTS FROM THE ORIENT

R. Kent Beattie, a plant explorer who has been searching the domains of the Formosa head-hunters and the forests of Korea and Japan for blight-resistant chestnuts to plant in American forests, has returned to Washington. Mr. Beattie is a forest pathologist of the U. S. Department of Agriculture.

During two and a half years Mr. Beattie collected about 250 bushels of chestnuts of native strains, and scions of about 90 cultivated varieties. He shipped these nuts and scions to Washington as fast as he collected them and the Department of Agriculture planted them in its forest nursery at Glendale, Maryland, to test their resistance to blight and their adaptation to the climate and soil of a new homeland. These plantings produced about 250,000 seedlings.

Last spring the department placed 73,000 seedlings grown from Mr. Beattie's 1928 collections with foresters and experiment stations in Connecticut, Massachusetts, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, Virginia, North Carolina, Georgia, Alabama, Tennessee, Kentucky, Louisiana, Ohio and Michigan for testing.

Pathologists and foresters hope that blight-resistant chestnuts eventually will be established throughout the chestnut-growing states, where blight is rapidly depleting the stands of native chestnut. The American chestnut is still the source of more than 50 per cent. of our vegetable tannin. Tests by the department show that the Japanese chestnut is an equally good producer of tannin. Mr. Beattie reached Japan in the summer of 1927. He visited the areas of Japan where the chestnut grows and arranged with official foresters, representatives of the Imperial Household, agricultural cooperative marketing associations and chestnut growers to ship nuts to him at Tokyo or Yokohama. After gathering chestnuts from every accessible region of Japan, Korea and Formosa, Mr. Beattie made a return trip around more than half of the globe, gathering information about the chestnut and related trees.

THE DE LAMAR LECTURES

The list of De Lamar Lectures in Hygiene this session at the School of Hygiene and Public Health of the Johns Hopkins University is as follows.

"The Rôle of the Anaerobic Bacteria in Human Pathology," Dr. M. Weinberg, professor at the Pasteur Institute, Paris, October 21.

"The Serotherapy of Medical and Surgical Infections Caused by Anaerobic Bacteria," Dr. M. Weinberg, professor at the Pasteur Institute, Paris, October 22.

"The Economic Aspects of Medical Care in this Country," Dr. Willard C. Rappleye, director of study, Commission on Medical Education, New Haven, Connecticut, November 4.

"Acid-fast Bacteria: Their Relation to Disease and the Need for Better Preventive Measures," Dr. William Charles White, chairman, Medical Research Committee of the National Tuberculosis Association, November 25.

"Recent Progress in Yellow-fever Research," Dr. W. A. Sawyer, associate director International Health Division, Rockefeller Foundation, December 9.

"The Epidemiology of Poliomyelitis," Dr. W. Lloyd Aycock, assistant professor of preventive medicine and hygiene, Harvard Medical School, January 6.

"Factors influencing Vitamin Distribution in Foods," R. Adams Dutcher, professor of bio-chemistry, Pennsylvania State College, January 27.

"Venereal Diseases," Dr. Thomas Parran, Jr., commissioner of health, State of New York, March 3.

"Hypersensitivity to Bacterial Proteins and its Rôle in Susceptibility and Immunity," Dr. W. B. Wherry, professor of bacteriology, University of Cincinnati, March 31.

"The Prevention and Cure of Narcotic Drug Addiction," Dr. George F. McCleary, deputy senior medical officer, Ministry of Health, England, April 14.

THE TEXAS ACADEMY OF SCIENCE

THE Texas Academy of Science held its annual meeting from November 28 to 29 at Baylor University, Waco, Texas, with a large attendance of members. The program, which consisted of twenty numbers, was given in three sections; the first was given over to the exact sciences; the second to the biological sciences, and the third to the educational sciences. Those giving the papers were widely distributed in their connections. The University, A. & M. College, Teachers Colleges and numerous denominational colleges were represented. The night of November 28 Dr. S. L. Brooks, president of Baylor University, entertained the academy with a banquet.

In the business meeting it was announced that the academy had received its charter from the state; that it had been affiliated with the American Association for the Advancement of Science; that its membership had grown within the last year from 79 to 300, and that it had issued Vol. XIV of the "Transactions and Proceedings." The academy adopted an amendment to its constitution providing for the formation of a Junior Academy of Science. Clyde T. Reed, the retiring president, was selected as chairman of the Junior Academy, with Miss Greta Oppe and Robert H. Cuyler as the other members.

The officers elected for the Academy of Science were J. K. Strecker, *president*, Baylor University; J. M. Kuehne, University of Texas, *vice-president Section I;* F. B. Plummer, University of Texas, *vice-president Section II;* W. J. McConnell, North Texas State Teachers College, *vice-president Section III*. Dr. S. W. Bilsing, A. & M. College of Texas, representative to the American Association Council, and H. B. Parks, San Antonio, *secretary-treasurer*.

The academy is entering its third year, as this is a reviving of the old academy, which existed from 1892 to 1915. So great is the interest shown in the work that the membership ordered the printing of a monthly bulletin and a volume of "Transactions and Proceedings" for next year.

PRESENTATION OF THE JOHN FRITZ MEDAL

THE John Fritz Medal, which had been awarded to Rear Admiral David Watson Taylor, retired, chief constructor of the United States Navy during the war, was presented at the annual dinner to new members of the American Society of Mechanical Engineers, given at the Hotel Astor on December 3 as part of the fifty-first annual meeting.

The award was made to Admiral Taylor "for outstanding achievement in marine architecture, for revolutionary results of persistent research in hull design, for improvement in many types of warships, and for distinguished service as Chief Constructor of the United States Navy during the World War." Mr. Bancroft Gherardi, chairman of the board which made the award, presented the medal after the recipient was introduced by Mr. Walter M. McFarland, past president of the Society of Naval Architects and Marine Engineers.

Another event at the dinner was the presentation of special badges to fourteen fifty-year members of the society. Mr. Thomas A. Edison was one of the fourteen. Mr. Fred A. Scheffler accepted the medal for him. The others were Ellwood Burdsall, Port Chester, N. Y.; John W. Cloud, London, England; J. S. Coon, Atlanta, Georgia; P. B. de Schweinitz, Bethlehem, Pennsylvania; Henry Marx, Cincinnati, Ohio; A. F. Nagle, H. F. J. Porter, Auguste A. Goubert and Francis H. Richards, all of New York City; Albert W. Smith, Ithaca; Ambrose Swasey, Cleveland; Edward N. Trump, Syracuse, and Walter Wood, Philadelphia. The badges were presented by Charles E. Gorton, vice-president of the society.

The speaker of the evening was Elliott Dunlap Smith, professor of industrial engineering at Yale University, and director of industrial investigations of the Institute of Human Relations, who spoke on the subject "Engineering Encounters Human Nature." There were also remarks by the president-elect of the society, Roy V. Wright, an address to the new members by Conrad N. Lauer, vice-president, and a roll-call of the new members by Calvin W. Rice, secretary. Lincoln Bush, past president of the American Society of Civil Engineers, presided. Ely C. Hutchinson, manager of the society, was the toastmaster.

The three other societies joining in awarding the John Fritz Medal are the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Institute of Electrical Engineers. The medal was established in 1902 in honor of John Fritz of Bethlehem, Pennsylvania, pioneer iron master and engineer, who was the first recipient. Others who have won the award include Lord Kelvin (1905), George Westinghouse (1906), Alexander Graham Bell (1907), Dr. Elihu Thomson (1916), General George W. Goethals (1919), Orville Wright (1920), Guglielmo Marconi (1923), Elmer A. Sperry (1927) and Herbert Hoover (1929).

SCIENTIFIC NOTES AND NEWS

President Hoover has sent to the Senate the nomination of Dr. George Otis Smith, director of the Geological Survey since 1907, to be chairman of the new Federal Power Commission. Dr. Smith is named for the long term, expiring on June 22, 1935.

The Swedish Medical Society has awarded its Pasteur Gold Medal to Dr. Emile Roux, director of the Institut Pasteur of Paris. The award is made every ten years.

Professor Max Planck, now vice-chancellor, has become chancellor of the Prussian Order for Merit of Science and Art, to succeed the late Professor Adolf von Harnack. Dr. Ludwig Hoffmann and Dr. Ulrich von Wilamowitz-Moellendorff become first and second vice-chancellors, respectively.

Sir Wilfred Grenfell delivered the inaugural address to the Royal Scottish Geographical Society in Edinburgh on November 21, and received the Livingstone Medal, which is the highest honor that the society can confer. The address was on "Labrador," the scene of Sir Wilfred Grenfell's life's work.

Dr. Ernst Anton Wülfing, professor of mineralogy and petrography at the University of Heidelberg, celebrated his seventieth birthday on November 27.

Dr. C. S. Myers, director of the British National Institute of Industrial Psychology, has asked to be released from the duties of the directorship, and has been appointed principal, in order that he may devote the whole of his time to the institute's research and educational activities. Dr. G. H. Miles, who has been assistant director for several years, has been appointed director and will take charge of the practical activities.

Dr. Laurence Vail Coleman, director of the American Association of Museums, was appointed to the executive committee of the International Museums Office at a recent meeting in Geneva of the International Institute of Intellectual Cooperation. The seven other members of the committee represent Belgium, England, France, Germany, Italy, Spain and Switzerland.

Due to the illness of Dr. A. O. Thomas, the treasurer of the Iowa Academy of Science, the executive committee of the academy has appointed Dr. W. F. Loehwing, of the Department of Botany of the State University of Iowa, to act as treasurer of the academy.

Nature reports that at the anniversary meeting of the British Mineralogical Society, held on November 4, the following officers were elected: *President,* Sir John S. Flett; *Vice-presidents,* Dr. G. F. Herbert Smith, Professor C. Gilbert Cullis; *Treasurer,* Mr. F. N. Ashcroft; *General Secretary,* Mr. W. Campbell Smith; *Foreign Secretary,* Dr. J. W. Evans; *Editor of the Journal,* Dr. L. J. Spencer.

Leave of absence has been granted to Professor Brash, dean of the faculty of medicine, of the University of Birmingham, and Professors Haswell, Wilson and Daly, to visit the United States as guests of the Rockefeller Foundation to inspect the buildings and equipment of medical schools in view of the building and development of the new medical school of the University of Birmingham.

Dr. Karl L. Muller, of the Forest Experiment Station at Munich, Germany, is spending several months in the Northern Rockies and the Pacific Northwest in search of the best climatic "race" of lowland white fir (*Abies grandis*) to meet the needs of southern Germany.

Mr. Melbourne Ward, of the Australian Museum, is spending a few weeks examining crustacea at the National Museum. On November 15 he gave an illustrated lecture before the Biological Society on "The Natural History of the Barrier Reef of Australia."

Dr. C. G. Abbot, secretary of the Smithsonian Institution, delivered on November 22 a lecture before the Royal Canadian Institute, on "Studying the Sun in Many Lands."

On the evening of December 2 at the University of Pennsylvania, Dr. Colin G. Fink, professor of electrochemistry at Columbia University, addressed the chemists and engineers of Philadelphia on "Combatting Corrosion with Chromium" covering in the main his researches of the last few years.

Dr. Albert Ernest Jenks, professor of anthropology, University of Minnesota, delivered an illustrated address on "Prehistoric Mimbres Culture" before a meeting on November 21, of the Sigma Xi Chapter of the Staff of Mayo Clinic, Rochester, Minnesota.

At the autumn meeting of the Colorado Chapter of the Sigma Xi, held on December 12 in the recently completed Union Memorial Building of the University of Colorado at Boulder, Professor Etienne B. Renaud, of the University of Denver, delivered an address on the archeological survey of eastern Colorado conducted by him last summer.

Dr. H. M. Johnson, head of the Simmons Investigation of Sleep at Mellon Institute, lectured at the University of North Carolina on November 5 and 6

on "The Logical Structure of Three Modern Psychologies" and on "Some Recent Experiments on Sleep." The lectures were given under the joint auspices of the university and the local chapter of Alpha Psi Delta, honorary psychological fraternity.

THE following lectures and clinics were given recently at the Duke University School of Medicine and Hospital: Professor M. Weinberg, of the Pasteur Institute, Paris, "Anerobic Infections and Serum Treatment"; Professor I. S. Ravdin, University of Pennsylvania Medical School, on "Diseases of the Gall Bladder," and Professor William Castle, of the Harvard Medical School, on "Deficiency Diseases in Relation to Anemias."

PROFESSOR JULIAN S. HUXLEY, honorary lecturer in King's College, London, and Fullerian professor of physiology in the Royal Institution, will deliver two lectures on biology at the New School for Social Research, New York, on January 8 and 15. The first lecture will deal with evolution; the second with problems of heredity and development. Following there will be a course beginning on January 2 of twelve lectures on "Modern Biology and Human Affairs," by Dr. Henry J. Fry, professor of biology at Washington Square College of New York University.

DR. ALBRECHT PENCK, professor of geography at the University of Berlin, was by invitation present at the celebration in London of the hundredth anniversary of the Royal Geographical Society. At its close he gave an address at the University of London on "The Relations between Europe and Central Asia."

THE American Mathematical Society held a regular meeting at the University of California at Los Angeles on November 29. An address was delivered by Professor H. F. Blichfeldt, professor of mathematics at Stanford University, on "The Method of Geometry in Numbers." Professor Harald Bohr, professor of mathematics at the University of Copenhagen, brother of Professor Niels Bohr, who is this year a visiting professor at Stanford University, spoke on "The Theory of Dirichlet Series."

THE North Jersey Section of the American Chemical Society meets at the Hotel Winfield Scott, Elizabeth, New Jersey, at 2:00 P. M., on Saturday, December 13. Dr. Hugh S. Taylor will address the section on "Catalytic Reactions in Aliphatic Organic Chemistry." At the conclusion of the address buses will take members to the Bayway Refinery of the Standard Oil Company of New Jersey, where they will visit the technical service, research and motor laboratories. They will then return to the hotel where an informal dinner will be served. Two addresses will follow the dinner, the first by Dr. Warren K. Lewis on the "Thermal Properties of the Higher Hydrocarbons," and the second by Dr. R. P. Russell on "Hydrogenation of Oils."

THE thirty-eighth annual meeting of the American Psychological Association will be held from December 29 to 30 at the University of Iowa, Iowa City, under the presidency of Professor Herbert S. Langfeld, of Princeton University. Members of the association are to be guests of the university at a special dinner on Tuesday evening, December 30. At this time the new laboratory will be formally dedicated and a number of psychologists will speak on the status of experimental psychology.

THE Colorado-Wyoming Academy of Science convened for its fourth annual meeting in the University of Colorado at Boulder on November 28 and 29. All the important educational institutions in Colorado and Wyoming were represented and over a hundred scientific papers were presented in the various sections. Dr. H. H. Marvin, president of the Nebraska Academy of Science and head of the physics department of the State University of Nebraska, was the guest of honor and delivered the opening address on "The Approach to Unity of Explanation in Physics" and "The Raman Effect." Papers were presented by Professor R. G. Gustavson, of the University of Denver, on "The Female Sex Hormone," and by Josephine Roche, president of the Rocky Mountain Fuel Company, on "Social Science and Social Action." The following officers of the academy were elected for the coming year: *President,* Professor Frank E. E. Germann; *Vice-president,* Professor P. E. Boucher; *Secretary,* Professor J. Harlan Johnson; *Treasurer,* Professor O. M. Dickerson.

THE International Astronomical Union, of which Sir Frank Dyson, of London, is president, will have its annual congress at the Harvard Astronomical Observatory in the first week in September, 1932. Many astronomers will be drawn to America at that time by a total eclipse of the sun which will be visible in New England. That meeting will be the fourth congress held by the organizations. The others have been in Rome in 1922, in Cambridge, England, in 1925, and in Leyden in 1928.

THE Seventh International Conference of Industrial Psychology (Technopsychology, *Psychotechnique*), will be held in 1931 in Moscow, under the presidency of Dr. I. Spielrein, of the Institute for the Protection of Labor. While the date has not been definitely determined, it will probably begin on September 15. Industrial psychologists who wish further information may correspond with Dr. W. V. Bingham, 29 West 39th Street, New York, and Professor

M. S. Viteles, University of Pennsylvania, Philadelphia, American members of the council.

It had been the intention, according to the *Journal* of the American Medical Association, to close the Internationale Hygiene-Ausstellung Dresden on October 12. In spite of bad weather, which cut down the attendance, nearly three million persons visited the exposition. But, in order to score the success in Germany and in foreign countries to which the exposition is entitled, a much greater attendance is needed. A large number of investigating commissions have visited the exposition. Since, in 1931, few, if any, large expositions are announced for Germany next year, the Dresden exposition will be opened again in 1931. The exhibit of modern hospitals and their equipment will be preserved complete. Many of the set-ups will be reorganized, and other set-ups entirely new will be added. Also the foreign exhibit, which is housed in the Staatenhaus, will be enriched by the addition of material, much of which, owing to the short time allowed for the preparation of the exposition of 1930, could not be assembled. A considerable amount of material from America has been promised. Another new set-up will be a general survey of Catholic missionary enterprises in foreign countries. To secure a large attendance of the public, a special and regular train service from all parts of Germany and from many points in foreign countries will be organized.

Industrial and Engineering Chemistry reports that an institute to popularize the study of chemistry, to aid in the development of chemical sciences and industries, has been established in the Soviet Union. The establishment will be known as the Museum Institute of the History of Chemistry and has been created upon the advice of the Higher National Economic Council. A credit of 15 million rubles (approximately $7,500,000) has been opened for the construction and development of the institute.

A gift of $2,500 for purposes of chemico-medical research at the Medical College of Virginia, Richmond, has been announced. At the request of the donor of the money his name has been withheld. This gift will make possible a full-time worker for one year in the department of chemistry. Other departments of the school of medicine will cooperate in plans already made for the special line of study to be undertaken and will share in the responsibility for the work as it proceeds.

The correspondent of the London *Times* at Stockholm reports that Professor Hertzberg has made an examination of the films taken by the Andrée Expedition in 1897 and has achieved greater success than was anticipated with their reproduction, twenty of them giving perfectly clear pictures. Twelve of them will be reproduced in the official record of the Andrée Expedition. The best prints show the balloon after landing on the ice, from which it would appear that the loss of gas and the formation of ice on the envelope of the balloon caused it to come down. Another picture shows Andrée with a Polar bear he has shot, and this is so clear that the bear's fur stands out distinctly. In addition to pictures showing the wonderful spirit maintained by the party, there is one of the party's camp, but it is uncertain whether it was a camp on the ice or on Kvitö Island. It is noteworthy that some of the films on being developed show that they are positives. Professor Hertzberg states that the edges of the films in some rolls were found stuck together, thus hermetically sealing the center, and this, helped by the low temperature, preserved them.

A cast of the fossilized skull and lower molar recently discovered at Chou Kou Tien, near Peking, has been presented to the British Museum (Natural History) by Mr. F. O. Barlow and is on view to the public in the Fossil Mammal Gallery at South Kensington for comparison with other skulls of primitive man. While the remains are of approximately the same age as those of the Ape-Man (*Pithecanthropus*) of Java, and the Piltdown man (*Eoanthropus*) found in the Sussex Weald in 1912, the juxtaposition of casts in same display-case now enables visitors to recognize the distinctions. The department of botany has received 152 natural-size water-colors of North American wild flowers from Mrs. Hosea B. Morse, who has enhanced the value of her gift by full botanical and biological notes.

Nature reports that an analysis of the literature of the Raman effect published up to the end of June of this year is given by S. Bhagavantam in the September number of the *Indian Journal of Physics*. Some three hundred and fifty references are dealt with—a large increase on the 150 listed by Dr. Ganesan last year in the same journal—and have been grouped under twenty-six heads, the first three of which contain book references and articles of a general character, and the remainder papers on special aspects of the effect. These are followed by an author index and an alphabetical list of the substances which have been studied, and there is a further list of almost a hundred other papers on light scattering which have been published by Indian authors since 1919.

Increased travel to the national parks during the past year is announced by Horace M. Albright, Director of the National Park Service. This heavier use of the national parks was the most remarkable when compared with the reduced use of transcontinental trains and of resorts generally. The national

park travel year ends on September 30 of each year. This year the number of visitors to the national parks totaled 2,818,618 as against 2,680,597 in 1929, an increase of 138,021. Yosemite National Park led in numbers, with 458,566 visitors. Mount Rainier was second, with 265,620. The national monuments as a whole suffered a loss, with 466,075 visitors as against 567,667 in 1929. A large part of this decrease, however, was the result of the abolishment last April of the Papago Saguaro National Monument, which last year reported 87,600 visitors. During the first six months of this year, the period of heaviest travel in the southwest, approximately 50,000 people visited this monument. The Petrified Forest National Monument in Arizona, with 105,433 visitors, led both in numbers and in point of increase. The 1929 visitors to this monument numbered 69,350. Director Albright was enthusiastic over the development possibilities of the area. Despite the reduction in the number of visitors to the monuments, the combined park and monument travel for 1930 is greater than that for any previous year with the exception of 1929.

THE council of the British Association have asked the government to give effect to the recommendations of the Royal Commission on National Museums and Galleries for the establishment of a National Open-Air Folk Museum. It is suggested that the Royal Botanic Gardens in Regent's Park could be utilized.

THE London *Times* reports that an expedition from the University of Cambridge is sailing for Mombasa early in December to carry out biological investigations of certain little-known lakes in East Africa. The particular objectives will be Lake Rudolf, Lake Baringo and Lake Edward. Several expeditions have been made to the better-known lakes, and in 1927 government surveys of the Victoria and Albert Nyanzas were made to investigate the economic value of native fishes. Lakes Rudolf, Baringo and Edward have never been scientifically examined, and it is expected that the expedition will bring home a large number of new forms of life, as well as information about the inter-relationships of the fauna and flora, about the chemistry and physiography of the lakes, and perhaps a solution of the interesting problem of the absence of crocodiles from Lake Edward. Another side of the work will be the extension of Mr. L. S. B. Leakey's recent Kenya archeological explorations northwards in the Great Rift Valley; it is hoped to find further archeological remains round Lakes Baringo and Rudolf. The expedition is being financed by the Royal Society, the Natural History Museum, the Royal Geographical Society, the British Association and other scientific bodies. It will be under the leadership of Dr. E. B. Worthington and other members from Cambridge will be Mr. L. C. Beadle as zoologist and Mr. V. E. Fuchs as geologist and surveyor.

DISCUSSION

BABYLONIAN MATHEMATICS

ALL the earlier accounts relating to the historical development of the quadratic equation have become antiquated during the last two years as a result of recent discoveries relating to the mathematical attainments of the Babylonians during a period of at least 1,500 years beginning about 2000 B. C. It is especially interesting to observe that this period overlaps that of the early Greek mathematical activity and hence it establishes a continuity in algebraic developments which had not been known to exist hitherto. According to a recent number of the *Quellen und Studien zur Geschichte der Mathematik*, a new publication to which Professor R. C. Archibald called attention in this journal,[1] we now know at least 19 Babylonian problems which give rise to quadratic equations, and with respect to 10 of these the details of the solutions are given. In some cases the method used corresponds to the modern method of completing the square and differs only from our modern procedure by omitting the double sign when the square root is extracted.

The Babylonian mathematics is of special interest in view of the fact that our division of the circle into 360 parts called degrees, and our division of the degree and the hour into 60 parts called minutes and of the minute into 60 parts called seconds can be traced back thereto. It has often been stated that the Babylonians employed a sexagesimal system of numerical notation. As a matter of fact this is not strictly true since they did not employ 59 different symbols for the first 59 natural numbers; neither did they employ a sexagesimal symbol corresponding to our decimal point to mark the starting-point of their integral numbers and their systematic fractions represented by multiples of negative powers of 60. A fully developed sexagesimal system of numerical notation has never been commonly used as far as we know. The early Babylonians do not seem to have possessed even an emptiness zero, but a symbol which was also used as a symbol of separation was employed later by them for this purpose.

[1] SCIENCE, 70: 67, 1929.

Since the Babylonians commonly employed only two distinct symbols to represent the first 59 natural numbers, *viz.*, a symbol for unity and a symbol for ten, their system of numerical notation can be more properly called a decimal system than a sexagesimal system. There is, however, a very striking difference between their system of notation and the systems employed by the other early nations, since their symbol for unity was used also to represent various positive and negative powers of 60, depending upon the relative positions, which are, however, frequently not clearly exhibited in their notations. Hence we meet here for the first time in the history of mathematics an approach to our modern positional notation where the same symbol is used to represent an infinite number of different numbers depending upon its position relative to the decimal point, either implied or expressed. When multiples of negative powers of the base are used to represent fractions, a symbol of separation, corresponding to our decimal point, is almost as important as an emptiness zero symbol, but the former has received much less attention on the part of mathematical historians than the latter.

In the periodical noted above Professor O. Neugebauer, of Göttingen, Germany, stresses the fact that the ancient Babylonians did not have a fully developed positional system of numerical notation but that it is likely that our modern system to the base 10 was influenced by their steps in this direction. In view of the fact that they made such important progress towards the solution of the general quadratic equation one might have expected that they would have easily mastered the simpler problem of completing their positional arithmetic by means of a symbol corresponding to our decimal point and by a much earlier and more common use of a symbol for an emptiness zero. The great importance of these apparently easy forward steps may be seen if it is noted that the translation of the numerical notations now frequently presents the greatest difficulties to the students of the ancient Babylonian literature. Just where one might have expected the greatest clearness one finds the greatest vagueness.

We are thus brought face to face with the fundamental fact of the history of mathematics—that unexpectedly advanced results are frequently found side by side with very crude ancient developments. It is therefore often very difficult for the mathematical historian to convey a correct picture of the actual attainments at a certain period of time. Naturally the most advanced developments are usually first considered and hence the beginner is apt to think too highly of the attainments of the ancient civilizations. The solutions of the quadratic equations to which we referred above are, however, also of great interest since they tend to exhibit the naturalness of this equation in our efforts to secure an intellectual penetration into our surroundings and hence they tend to dignify this equation as an intellectual tool. They also tend to emphasize the fact that mathematical history is a subject that must be frequently revised in order to be up to date even as regards very elementary results.

G. A. MILLER

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A FOSSIL FROG, INDOBATRACHUS NOBLE, FROM THE EOCENE OF SOUTH-WESTERN INDIA

A FEW months ago G. K. Noble[1] reported upon his study of a number of specimens of a fossil anuran which, from the geographical locality and geological horizon as well as general resemblance to the descriptions, seems to be what was first named *Rana pusilla*,[2] later called *Oxyglossus* by Stoliczka,[3] now *Oxydozyga*.[4] Noble regards the form as an "archaic bufonid" closely related to the "archaic bufonids" found to-day in Australia. Noble writes, "The discovery of a toothed bufonid in the Eocene of India lends support to the theory of a northern origin for the Australian frog fauna."

Noble's "toothed bufonids" now living in Australia are regarded as Leptodactylids by other herpetologists. These apparently arose in South America from true bufonids. The family Bufonidae may, for convenience, be divided into two divisions, the first including archaic forms of pre-Cretaceous or early Cretaceous origin in southern lands and belonging to genera other than *Bufo;* the second division including only the comparatively modern genus *Bufo,* which probably evolved in southeastern Asia in the Cretaceous period. The genera of the first division occur to-day in Australia, in northern South America, in Java and Borneo, Ceylon, southern India and in tropical Africa. From ancient bufonids evolved apparently: (1) *Bufo,* in southeastern Asia—*Aelurophryne* seems an intermediate form from this general locality. *Bufo* has spread to all parts of the world accessible since, say, the middle Cretaceous; (2) the Hylidae arising apparently in the Guiana-Brazil highlands after they united with the Ecuadorean island; (3) the Lepto-

[1] G. K. Noble, "The Fossil Frogs of the Intertrappean Bed of Bombay, India," *Am. Mus. Novitates*, No. 401, February 8, 1930.

[2] Owen, "On the Batracholites Indicative of a Small Species of Frog (*Rana pusilla*, Owen)," *Quart. Journ. Geol. Soc., London*, III, 1847.

[3] Stoliczka, "Osteological Notes on *Oxyglossus pusillus* (*Rana pusilla*, Owen) from the Tertiary Frog-beds in the Island of Bombay," *Mem. Geol. Survey India*, VI, 1869.

[4] "Kuhl," quoted by Tschudi in synonymy of *Oxyglossus*, *Mem. Soc. Sci. Nat. Neuchatel*, II: 85, 1838.

dactylidae, arising perhaps further south, in Patagonia, and spreading by way of Antarctica to Australia. But these three families so merge into one another that intermediate forms, especially fossil, may be difficult to assign. *Indobatrachus,* from its distribution, would seem to be a true archaic bufonid rather than a Leptodactylid.

The presence of *Indobatrachus* in the Eocene of southwest India has to me a different meaning from that indicated by Noble. During the Triassic period the great southern continent which I have called Equatoria (Gondwanaland[5] plus South America) apparently included southern India. So also, according to usual opinion, did the more restricted Jurassic continent, Gondwanaland. The presence of one of the more archaic genera of Bufonidae in the Eocene of southern India seems to show merely that one of these ancient bufonids, all of southern origin, persisted until Eocene times in northern Equatoria, or rather in a persistent fragment of this old southern continent, a fragment which has now established connection with northern land after the disappearance of the water channels of the archipelago which once lay between them.

To the biogeographer the word continent implies a region of free faunal and floral interchange. It is important to treat the biotic evidence with full tentative initial acceptance, slurring none of it, but giving frankly the conclusions to which it would most naturally lead. Such conclusions from the biotic data are then open to criticism from all germane sources. A well-nigh overwhelming mass of biotic data seems to point convincingly to faunal and flora interchange during Mesozoic or early Tertiary time between the southern continents, interchange which was itself southern and not by way of any northern lands. The familiar mammalian data indicating chiefly northern origin and southward distribution of mammals in the Tertiary do not militate against the general biotic evidence for pre-Tertiary or early Tertiary east and west communication between the southern continents. Indeed the biotic data show a sub-Antarctic fauna and flora in Antarctica, the sub-Antarctic islands, Australia, New Zealand, southern South America and, to a less extent, Africa, which seems as truly a unit as is any other faunal and floral unit. South Africa's connection was apparently not of long duration.

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[5] The name Gondwanaland has been applied by some authors to the Jurassic continent, Australia plus southern India plus the Indian Ocean Lemuria, including Madagascar, plus Africa. Others have applied the name Gondwanaland to this great southeastern land mass plus its Triassic extension to the west across the Atlantic Ocean and including South America. I have used the name Equatoria for this larger, Triassic continent, thus avoiding ambiguity.

NEW TYPES OF PLANTS IN FLORIDA

Florida, being practically isolated by large bodies of water from other countries having a similar climate, was probably quite slow to acquire tropical and subtropical forms of plants till man intervened. Since that event, however, new types have appeared in the state with increasing frequency, taking their place among the native vegetation. One such accession, *Cassia rotundifolia* Pers. or *Chamaecrista rotundifolia* (Pers.) Greene, was discovered in June, 1930, on the grade of a branch line of the A. C. L. Railroad which runs from St. Petersburg, Florida, to Sanford, Florida. So far as I can learn this plant grows nowhere in the United States, except for a distance of not more than 500 feet on the railroad embankment near Palm Springs, about three miles west of the town of Longwood, Florida, where it grows vigorously and fruits abundantly.

From my examination I am unable to make this species fully conform to the published descriptions of either *Cassia* or *Chamaecrista.* It possesses the distinctive leaf and stamen characteristic of *Cassia.* It is also but slightly sensitive and is without leaf glands. On the other hand, the single axillary flower on a twisted peduncle, the slightly unequal petals and the distinctly flat pods are features possessed by *Chamaecrista.* It may possibly deserve to be given a new genus name.

Conjecturally, one may readily account for the presence of the plant where it was found. It is a native of Mexico and the seeds may easily have been included with the packing of a boat shipment to some of the ports around Tampa Bay; from there by train to their destination on the railroad in Seminole County.

Solanum jamaicense was first brought to the U. S. D. A. Laboratory, at Orlando, Florida, about June 15, 1930, by Messrs. W. H. Pope and W. D. White, wild host scouts searching for hosts of the Mediterranean fruit fly. In a letter from Dr. A. Wetmore, of the National Museum, he states that this species had not formerly been reported as growing in the United States.

The plant was found near St. Cloud, about 25 miles to the southeast of Orlando. A visit to the locality was made on July 19 and the *jamaicense* was found growing in considerable numbers on a slight rise along the margin of what is called East Lake. The elevation is not more than 8 or 10 feet above the high-water level of the lake, and the ridge is about 100 yards wide by 2¼ miles long and lies between the lake and a slough. There is no indication that the location has been a house site, and the nearest house is now more than one half mile away. Trees and shrubs, such as *Tamala humilis, Acer floridanum, Ilex*

cassine, Ilex glabra, Morella cerifera, Vitis rotundifolia, Taxodium distinctum, etc., form a dense growth over most of the area and appear to be many years old. The *Solanum* grows around the edge of the denser portion of the vegetation. The *jamaicense* seems to be thrifty in the habitat and fruits abundantly and when last seen bore all stages from bloom to ripe berries.

Aeschynomene americana L. has been observed growing and seeding profusely in waste low pine in Orange, Polk and Hillsborough counties, Florida. It seems well suited to the new environment.

MAURICE MULVANIA

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DREIKANTER IN WYOMING AND MONTANA

WHILE engaged in geologic work during the past summer in company with Dr. C. K. Wentworth, associate professor of geology, Washington University, St. Louis, the attention of the writer was called to several occurrences of dreikanter or wind-etched pebbles in Wyoming and southern Montana.

Text-books generally tell us that dreikanter are found in desert areas where there is an abundant supply of loose sand. With this conception in mind, the occurrence of the dreikanter found during the past summer is doubly interesting.

The most perfect examples of dreikanter were found on the western slope of the Wind River Mountains in western Wyoming. Here is an ancient land surface, apparently undisturbed during recent geologic time, with a relief low enough to allow for the free sweep of the wind. The pebbles were partly buried, with the upper etched portion protruding from the ground. Many finely polished specimens with the three angular edges so characteristic of true dreikanter were found at this locality. Far exceeding these in number were those showing only one well-developed angular edge (Einkanter), and others in which the upper portion of the pebble had been removed by the sand-blast action. The average size of the pebbles was about that of a lemon, although many larger specimens were found. The largest seen was a very well-developed dreikanter boulder which measured 24 inches long, 16 inches high and about 14 inches wide.

Another Wyoming locality between Rawlins and Medicine Bow yielded numbers of wind-etched cobbles of various sizes. Here the shaping of the individual cobbles had not progressed to completion, but a large proportion of the boulders studding the surface showed definite evidence of sand-blast action, many of them with characteristic einkanter shape. Wind-etched cobbles were also found in the neighborhood of Bosler, Wyoming.

The surface of terraces in the valley of the Yellowstone River east of Livingston, Montana, were found to contain numbers of etched cobbles, only a few of which showed a definite shaped dreikanter profile. Here, as elsewhere, were found many einkanter, but these were far outnumbered by fragments showing only partial etching and shaping.

It is interesting to note that at none of these localities does the country show true desert characters. All are in areas of scanty rainfall and sparse vegetation, but the amount of loose sandy material is small. Again, it may be worthy of mention that the better shaped cobbles were found in localities where the ground was not too thickly studded with rock fragments.

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DEMONSTRATIONS IN CYTOLOGY

THE teaching of cytology requires abundant microscopic demonstrations to acquaint the student with factual evidence of the different topics discussed in the lectures. At the present time cytologic investigation is so diversified and specialized that it is impossible to prepare adequate material for this purpose. To overcome this difficulty, the writer proposes to establish a mutual exchange of slides among the many investigators in cytology. The following plan is submitted as a tentative procedure.

(1) The writer offers to exchange preparations of polar body formation, fertilization, segregation of germ-cells and cleavage stages up to blastoderm formation in *Drosophila melanogaster* and Cerebratulus for any other preparations of great cytologic interest.

(2) From the slides thus received the writer will select some for his own collection and offer the remainder to all others who are interested on the basis of mutual exchange. Slides will be itemized on a mimeographed list.

The writer discussed this proposition with several cytologists in Woods Hole this summer and it was approved by all. Most investigators have duplicate preparations or some which can not be used in their work but would serve a useful purpose in general cytology. Instead of discarding such preparations, they should be put into service to demonstrate cytologic phenomena.

Teachers of cytology who wish to cooperate in this mutual exchange should label the slides carefully, and if the point of interest is limited to a small field, the area should be marked.

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NEW YORK UNIVERSITY

SPECIAL CORRESPONDENCE

THE RUMFORD FUND

THE Rumford Fund of the American Academy of Arts and Sciences was established by Benjamin Thompson, Count Rumford, physicist and administrator, through a gift of five thousand dollars to the American Academy, in July, 1796, for a medal or premium to be awarded at regular intervals to authors of the most important discoveries or useful improvements in light and heat, in any part of the continent of North America or in any of the American islands.

The American Academy had, in the earlier years, certain difficulties in administering the fund, and applied, in 1831, to the Supreme Court of the Commonwealth of Massachusetts for instructions. The court issued a decree which enabled the academy to apply part of the income from the fund for grants to researchers in light and heat. Since 1833, the academy has maintained a standing committee of seven fellows, known as the Rumford Committee, which makes recommendations to the council for the award of the Rumford Premium, and also makes grants to suitably qualified researchers in light and heat.

The thirty-five recipients of the Rumford Premium to date, commencing with the first award in 1839, have been Hare, Ericsson, Treadwell, Clark, Corliss, Harrison, Rutherford, Draper, Gibbs, Rowland, Langley, Michelson, Pickering, Edison, Keeler, Brush, Barus, Thomson, Hale, E. F. Nichols, Acheson, Wood, Curtis, Crafts, Ives, Stebbins, Coolidge, Abbot, Bridgman, Lyman, Langmuir, Russell, Compton, E. L. Nichols and Plaskett.

The Rumford Committee has also made more than two hundred and eighty grants of money, ranging from \$25 to \$500, to researchers, the average amount since 1839 having been about \$270. These grants are for apparatus, materials or experimental equipment, but not for the payment of assistants. They are also made towards the printing of researches on light and heat, subjects in which Count Rumford was particularly interested. More recently, however, the subject of X-rays has been accepted by the committee as coming within the scope of the fund.

Persons making application for grants from the Rumford Fund are expected to inform the committee of the nature and method of the research, so that a clear judgment can be formed as to whether it comes within the scope of the fund; also as to whether any similar applications have been made for grants from other funds for the same research. Researches aided by the Rumford Fund may be published in any place or form, with the proviso that due recognition be made therein as having been aided by the fund. A complete copy of each such publication should be presented to the academy.

Applications for grants should be addressed to the Chairman, Rumford Committee, American Academy of Arts and Sciences, 28 Newbury Street, Boston, Mass. Such an application may be made by any duly qualified person in North America, or any of the American islands. It should specify the nature of the research and the pecuniary amount desired.

A. E. KENNELLY,
Chairman of the Rumford Committee

QUOTATIONS

THE WORK OF DR. KARL LANDSTEINER

KARL LANDSTEINER, since 1922 a member of the Rockefeller Institute for Medical Research in New York, is the recipient of the 1930 Nobel Prize in medicine. Since the beginning of his scientific career, more than thirty years ago, Landsteiner has made contributions of great significance to medical science. He has thrown much new light on the nature of paroxysmal hemoglobinuria. With Popper he first produced infantile paralysis in the monkey, a demonstration that was followed by the intensive experimental work to which we owe practically all that is known of the nature of the causative agent of the disease. Undoubtedly Landsteiner's greatest and most brilliant work is his study through many years of fundamental problems in immunity, particularly the chemistry of the specificness of immune reactions. In this field, that is, the relations of the mechanisms of immunity to chemical structure, he has been and is a great leader, making no hasty or extravagant claims but standing always on solid ground. The main motivation for awarding to him the Nobel Prize in medicine appears to have been his discovery of the human blood groups or the phenomenon of iso-agglutination. His first statement about human iso-agglutination appears in a footnote to an article in 1900 about the antifermentative, lytic and agglutinating actions of the blood serum and lymph. In this footnote he says that the serum of normal persons agglutinates not only the blood corpuscles of animals but also the corpuscles of other persons. It remains, he continues, to determine whether this phenomenon depends on natural, individual differences or on injurious influences perhaps of bacterial nature. In fact, he had found the action especially pronounced in blood from patients with severe diseases. Before long he demonstrated conclusively by careful observations that iso-agglutination depends on individual, physiologic differences in the blood. Here was a concrete and clean-cut discovery that was destined to have wide applica-

tions. Landsteiner himself early pointed out the possibility that iso-agglutination might prove of importance in the identification of blood for medicolegal purposes and also in blood transfusion. The practical use of blood grouping, now universal, to exclude incompatible donors in therapeutic transfusion was initiated and developed especially in this country. When it became established that the factors on which blood grouping depends are transmitted according to the laws of heredity, determination of the blood groups was applied to the study of interracial relationships and of problems of parentage. When Landsteiner described the blood groups, he was an assistant under Weichselbaum in the pathologic-anatomic institute of the University of Vienna. No doubt he little thought then that that work was to bring him such rich reward thirty years later, but he did the work and carried out the observations as carefully and accurately as he could without any consideration or motive other than to find out all in his power about something new and obscure. Thus his work became the starting point in a series of advances in knowledge and achieved its international and well-merited recognition.—*The Journal of the American Medical Association.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN ELECTROMAGNETIC TOUCH-STIMULUS REACTION KEY

FOR laboratory investigation of tactual reaction time, the author has constructed and employed with success at the Florida State College for Women an electromagnetic touch-stimulus reaction key which can be controlled at a position remote from the recording chronoscope. The apparatus described below is an improved form of the author's original key. The extended rocker of the original key was provided with an elongated terminal perforation through which a metal rod was activated vertically by means of the armature of a modified electromagnetic sounder. By substituting linear solenoid motion for the leverage armature motion which characterized the earlier model, any angular displacement of the plunger rod is completely eliminated.

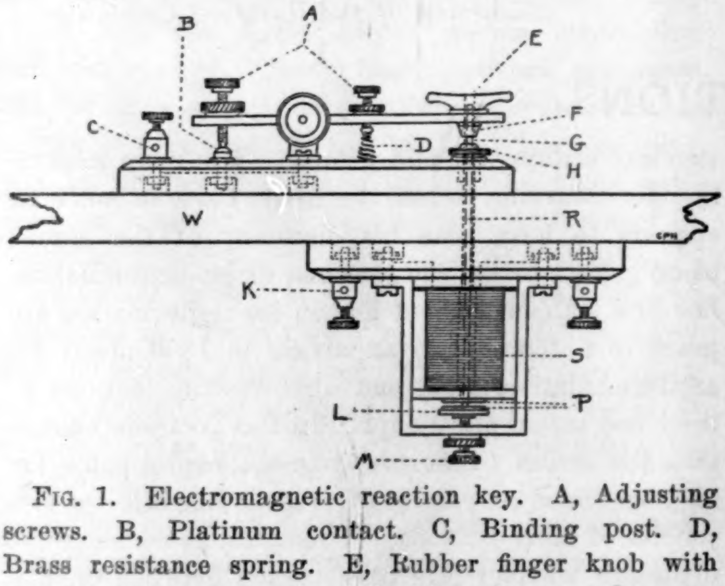

FIG. 1. Electromagnetic reaction key. A, Adjusting screws. B, Platinum contact. C, Binding post. D, Brass resistance spring. E, Rubber finger knob with circular hole in center through which plunger rod passes. F, Heavy platinum contact. G, Hard rubber plunger rod. H, Adjusting screw which serves as binding post. K, Binding post connecting electromagnet. P, Thin felt cushions. S, Magnetic coil wound with 22 B.S. gauge double cotton covered wire. R, Plunger rod passing without contact through table top. L, Soft iron plate to which plunger rod is affixed. M, Adjusting screw to vary the distance between plunger plate and magnet core.

The reaction key (Fig. 1) is simple in design and is substantially constructed of hard brass to withstand considerable laboratory use and punishment at the hands of the beginner. The reaction key is employed in conjunction with the Heinlein duo-circuit stimulus key. The latter key, consisting of two conjoined but mutually insulated parallel rockers balanced on a single fulcrum, acts as a nicely adjusted double-pole single-throw circuit breaker. Both reaction and stimulus keys are inserted in the conventional Dunlap chronoscope circuit. The complete electrical hookup is indicated in Fig. 2.

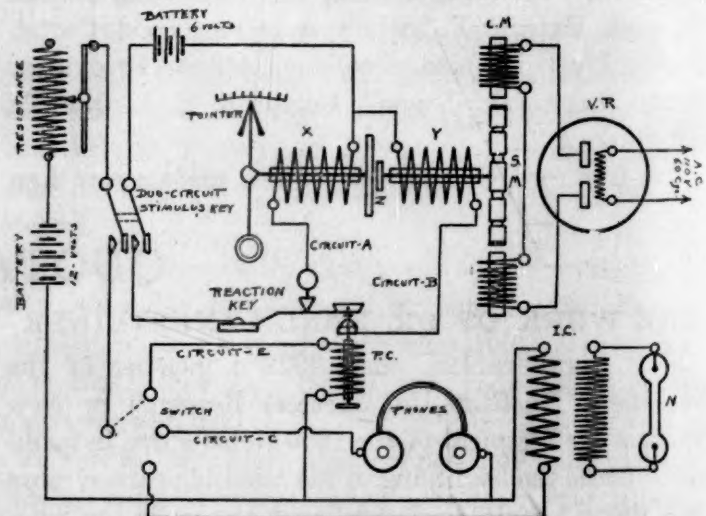

FIG. 2. Chronoscope hookup. X, External clutch coil. Y, Internal clutch coil. Z, Clutch plates. SM, Armature of synchronous motor. CM, Motor field pole. VR, Valve rectifier. PC, Plunger coil of touch reaction key. IC, Induction coil. N, Neon tube.

When the finger knob of the duo-circuit stimulus key is depressed, through completion of the primary and secondary circuits, both the internal electromagnetic coil of the chronoscope friction clutch and the electromagnetic coil of the touch-stimulus reaction key are simultaneously activated. If the internal resistance, magnetic affinity and working load of each electromagnetic coil are approximately the same, the

dynamic lag characteristic of the first coil should approximately equal the dynamic lag characteristic of the second coil. Any existing lag difference will not vitiate accurate timing provided that the extent of such lag difference is determined, since the existing difference itself is a constant when the parallel circuit E.M.F. is constant.

In actual experimentation, the director first presents to the subject a "get ready" signal by depressing a special circuit key which may either illuminate a small tungsten lamp or activate a high frequency buzzer. This preliminary signal is afforded for the purpose of informing the subject just when to place his finger on the concave cushion knob of the reaction key. After an appropriate interval, the time value of which may be controlled by a seconds pendulum and varied at the discretion of the director, the experimenter then depresses the duo-circuit stimulus key. Depression of the reaction key followed by depression of the stimulus key closes circuit B (Fig. 2), thereby forcing the plunger rod through the finger knob aperture of the reaction key simultaneously with the initial movement of the pointer on the time dial of the chronoscope. The subject has been previously instructed to release his finger from the reaction key the instant that he perceives the plunger rod touch his skin. Release of the reaction key by the subject provides a circuit transfer from B to A which magnetizes the external coil X of the chronoscope clutch and thus attracts the dial pointer outward to a state of rest. Since a valve rectifier (VR) is inserted between the synchronous motor of the chronoscope and the alternating circuit main, the conventional 60-cycle input is converted into a 30-cycle input (sixty impulses per second) which provides a dial measuring unit of one six-hundredth of a second. According to Dunlap, a measuring unit of two sigma is small enough for practical purposes. The investigator should never utilize alternating current that is not centrally synchronized.

If the experimenter wishes to investigate reaction time to auditory and visual stimuli in addition to reaction time to touch stimuli, the necessary apparatus adequate to provide such sensory stimulation may be inserted in the same chronoscope circuit without difficulty. A three-point switch shifts the stimulus control current from the plunger coil (circuit E) either to a pair of 2,000 ohm headphones (circuit C) or to an induction coil which is directly connected with a neon lamp (circuit D). The same reaction key may be used for each of the three types of presented stimuli.

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A METHOD TO SOFTEN TISSUE ALREADY IMBEDDED IN PARAFFIN[1]

THE method is believed to be generally applicable. It was first tried by the writer on lily ovary tissue in Professor W. C. Coker's laboratory at the University of North Carolina. The most convincing results, however, have just this summer been obtained while doing histological work on the pineapple leaf.

The pineapple leaf in a fresh condition, though rigid, is not particularly tough. In paraffin it is definitely brittle, and without softening treatment the tissue crumbles on the knife instead of cutting.

The following method has been used very successfully in obtaining smooth, even and straight paraffin ribbons of sections of pineapple leaf.

1. Rectangular pieces of leaf not over 4 by 10 mm, preferably smaller, are fixed in FAA. The pineapple leaf varies in thickness from less than 1 mm to about 2 mm.

2. Dehydrate and clear in the usual way with ethyl alcohol and xylol.

3. Infiltrate and imbed in paraffin. Infiltration must be as nearly perfect as possible. Paraffin of melting-point 52°–54° C. has been used on account of lack of that of 56°–58° C., which it is believed would be better suited for our laboratory temperature range of 27°–29° C. during the daytime. At this temperature sections could not be cut continuously successfully at less than 12 μ.

4. Shape the imbedded tissue ready for cutting. Trim the two edges and one end so that the leaf tissue will be directly exposed. This is very necessary to facilitate the subsequent treatment. If the piece is long, both ends may be exposed. Drawing the edge of a sharp, thin razor blade across the surface of the paraffin block to which the leaf tissue is nearest will also help, but is not necessary unless large pieces are used.

5. Store in 95 per cent. alcohol (at a temperature of about 30° C.) containing enough carbol fuchsin to make it pink. If material turns red throughout when transferred to water containing a little carbol fuchsin, infiltration was not complete. Such material will not cut satisfactorily. Paraffin is very slightly soluble in 95 per cent. alcohol at 28°–30° C.

Two to 4 days is sufficient to make the younger leaf tissue cut satisfactorily. Two to 3 weeks improves it and is necessary for the older leaf tissue.

6. Transfer to water 2 to 24 hours before trying to cut.

7. If, after half a block has cut well, the ribbon

[1] Since this announcement went to press, more definite results have been obtained and will be published later. The work is being continued in the Botanical Laboratory of Johns Hopkins University.

begins to twist and fold, place the material in water again.

The method is not recommended for tissue which is tough in a fresh condition, nor will it take the place of a sharp knife. The writer prefers a regular microtome knife, stropped at frequent intervals, to any of the razor blade holding devices. Investigations are to be continued along this line to find a water or alcohol soluble substance which has greater softening qualities than pure water that can be used successfully in connection with the 95 per cent. alcohol treatment to soften tissue which is definitely tough in a fresh condition.

Chamberlain recommends a method used by Dr. Land of storing the paraffin cakes in water. The writer is not in a position to make comparisons. Obviously, however, the 95 per cent. alcohol treatment upon the partially exposed material would facilitate the infiltration of water later. It is hoped that this modification of Dr. Land's method may meet with some favor among paraffin workers.

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SPECIAL ARTICLES

IMMUNIZATION WITH ALUMINUM HYDROXIDE MIXTURES OF POLIOMYELITIS VIRUS

THE recrudescence of poliomyelitis in the United States and Europe during the past two or three years has led to a restudy of the disease from many points of view. This brief report deals with the experimental evidence that the virus of poliomyelitis, inactivated by adsorption on particles of aluminum hydroxide, is still capable of producing immunity when inoculated into *Macacus rhesus* monkeys. Previously several investigators had shown that a variety of viruses could be adsorbed and rendered ineffective by a number of colloidal and particulate chemical substances. No one seems, however, to have tested the inactivated materials for the production of artificial, active immunity.

The aluminum hydroxide employed was the type C suspension of Willstätter containing 22.5 grams of aluminum per liter. The virus was either Berkefeld N filtrate of fresh monkey pooled virus,[1] or suspension of glycerolated material of the same strain. Mixtures of virus and suspension were allowed to stand 30 minutes at room temperature. The experiments carried out were of three types: simple observations on the inactivation of poliomyelitis virus by aluminum hydroxide; studies of the effect of the pH of the mixture on the inactivating power; and determinations of the value of the inactivated virus in the production of immunity. Intracerebral inoculations of the aluminum suspension alone were without pathological effect.

In respect to these three tests it was found first, that the filtrate and aluminum hydroxide mixed in equal volumes became inactive; second, that inactivation was promoted by acid (5.5) and prevented by alkaline (8.8) reactions; and third, that repeated subcutaneous injections of the inactivated virus led to active immunity.

The immunity thus induced was tested in three ways. First, glycerolated virus was repeatedly instilled into the nostrils. All the previously treated animals resisted infection, although the control developed typical poliomyelitis. The second test, carried out 28 days after the first, consisted of intracerebral inoculation of fresh virus. Of three treated animals so tested, one developed poliomyelitis, as did the control, and two resisted infection. The third test was made with the blood serum of the treated monkeys. Each of the three sera was tested separately and each neutralized the virus.

It may, therefore, be concluded that the virus, when adsorbed on aluminum hydroxide, is incapable of producing poliomyelitis, but still capable of inducing active immunity in *Macacus rhesus*. In a small series of animals thus immunized, no symptoms of experimental poliomyelitis arose, and in one only was the degree of immunity, although adequate to protect against nasal instillation, insufficient to protect against intracerebral injection of virus. That all three treated monkeys developed immunity is shown by the serum neutralization tests.

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1 Rhoads, C. P., *Jour. Exper. Med.*, 49: 701, 1929.

THE EFFECT OF TESTICLE EXTRACT AND NORMAL SERUM ON THE GROWTH OF A TRANSPLANTABLE EPITHELIAL TUMOR OF THE RABBIT[1]

EARLIER investigations in this laboratory[2, 3] have shown that extracts of the testes considerably enhance

1 From the laboratories of the Rockefeller Institute for Medical Research.

2 F. Duran-Reynals, *Soc. Biol.*, 1928, 99, 6; *J. Exp. Med.*, 1929, 50, 327.

3 F. Duran-Reynals and J. Suñer Pi, *Soc. Biol.*, 1928, 99, 1908.

the infectivity of vaccine virus and staphylococcus, while blood serum interferes with the action usually observed with these agents. These observations have been extended by Hoffman,[4] who has demonstrated the same phenomena with other filterable viruses and by Pijoan[5] with many other bacteria.

The present report deals with the effect of testicle extract and serum on the Brown-Pearce rabbit tumor,[6] a malignant, transplantable neoplasm of epithelial origin. In each experiment, three sets of test inoculations were made as follows: A suspension of the tumor cells was made with (a) an equal volume of testicle extract, (b) an equal volume of normal rabbit serum, (c) an equal volume of Ringer's solution as a control. These mixtures were incubated for 2 to 3 hours at a temperature of 37° C. and then injected intradermally in the shaved skin of the side of the body. Each rabbit was inoculated in one or more areas with each test mixture.

The results obtained in 10 rabbits inoculated in 84 different areas are shown in the accompanying table.

TABLE I

EFFECTS OF TESTICLE EXTRACT AND SERUM ON THE BROWN-PEARCE TUMOR

Tumor cell suspension plus	Number of inoculations	Larger growth than control	Same growth as control	Smaller growth than control	No growth
Rat testicle extract	16	0	0	2	14
Rabbit testicle extract	16	0	1	6	9
Rabbit serum	32	19	10	3	0
Ringer's solution (control)	20				0

In addition, an experiment carried out with the intratesticular inoculation of tumor tissue and rat testicle extract resulted in a less active primary growth and a greatly decreased distribution of metastases as compared with the results obtained by the intratesticular inoculation of suspensions prepared with Ringer's solution. This result is an apparent paradox, for the method used in carrying this tumor is by intratesticular injection, with which active growth is usually associated.

It may be concluded from these experiments that testicle extract exerts an inhibitory effect on the growth of a transplantable rabbit tumor, while normal rabbit serum, on the contrary, appears to stimulate its growth. These findings are in contrast to those obtained with viruses and bacteria, in which the testicle extract augments and normal serum inhibits the effects of these agents.

F. DURAN-REYNALS

[4] D. C. Hoffman, *J. Exp. Med.* (in press).
[5] M. Pijoan, *J. Exp. Med.* (in press).
[6] W. H. Brown and L. Pearce, *J. Exp. Med.*, from 1923 to 1929.

THE NECESSITY AND FUNCTION OF MANGANESE IN THE GROWTH OF CHLORELLA SP.[1]

THE importance of manganese in plant growth has been emphasized by the experiments of McHargue,[2] and more recently Samuel and Piper[3] have shown very clearly its essential nature for a fairly large number of species of seed plants. In the experiments of the latter workers practically no development of the plants beyond the seedling stage was obtained without manganese. Titus and Cave[4] have also shown the beneficial effect of manganese in hemoglobin building in the cases of animals made anemic on a whole milk diet. The necessity of manganese for a single-celled organism has not been shown and is of fundamental importance.

In connection with my own studies on iron in relation to Chlorella sp., a unicellular green alga, it has also been found that manganese is essential for growth. Increases of from 10 to 600 fold in the growth have been obtained by the addition of one part of manganese in five million parts of culture solution from which the manganese had been removed by adsorption on calcium phosphate. The accompanying tables present the data from two experiments which are typical of many performed. The experiments were carried out in pure culture.

TABLE I

THE NECESSITY OF MANGANESE FOR THE GROWTH OF CHLORELLA SP.

pH 7.0			pH 8.0		
Cult no.	Manganese	Dry weight	Cult no.	Manganese	Dry weight
1	none	2.6 mgs	9	none	0.6 mgs
2	"	5.1	10	"	0.4
3	"	2.2	11	"	0.2
4	"	0.9	12	"	0.1
5	1: 5,000,000	58.7	13	1: 5,000,000	77.2
6	"	57.1	14	"	45.7
7	"	64.7	15	"	52.8
8	"	60.3	16	"	53.2

The results shown in Table I demonstrate the necessity of manganese for Chlorella sp., since there is practically no growth without it. At pH 7.0 the increase due to manganese is about 17 fold and at pH 8.0 about 170 fold. The fact that there is more

[1] The investigation upon which this article is based was supported by a grant from the Heckscher Foundation for the Advancement of Research established by August Heckscher at Cornell University.
[2] *Ind. and Eng. Chem.*, 18: 172–175, 1926.
[3] *Ann. Appl. Biol.*, 16: 493–524, 1929.
[4] SCIENCE, 68: 410, 1928.

TABLE II

THE EFFECT OF CONCENTRATION OF MANGANESE ON THE GROWTH OF CHLORELLA SP.
pH 8.0

Concentration manganese	0	1 to 5,000,000	1 to 1,000,000	1 to 500,000	1 to 100,000	1 to 50,000
Dry weight mgs. av.	1.4(4)*	52.9(4)	53.7(4)	48.1(4)	36.2(3)	11.9(3)

* The figures in parenthesis refer to the number of cultures included in the average.

growth without added manganese at pH 7.0 may be due either to the difficulty of completely removing the manganese impurity or to the greater ionization of the manganese at this reaction.

In Table II the toxicity of manganese is also shown as the amount added is increased. It should be stated that to each culture of the above experiments was added 0.1 mg of iron and 0.04 gms of sodium citrate, and therefore soluble iron which is essential for this organism[5] was not a limiting factor. An important point in connection with these experiments is that the alkaline limit for the growth of this species as reported by Wann and Hopkins[6] must now be extended to higher pH values since pH 8.0 is very close to the limiting reaction reported by them. Other experiments show that, when manganese is added to manganese-free cultures which have shown no development of the organism in two weeks, growth then begins. The cells with which the cultures were inoculated were not dead but were unable to develop without manganese. I have also found that manganese will not replace iron—both are essential.

In most of the literature on manganese an explanation of its action has not been attempted. The present writer wishes to suggest that manganese functions physiologically in an indirect manner by its action on the state of oxidation of iron. In other words, manganese tends to control the ratio $[Fe^{++}] : [Fe^{+++}]$ in the culture or in the cell. Experiments *in vitro* have shown that the reduction of ferric iron to ferrous which is brought about slowly by sodium citrate tends to be prevented by the presence of manganese. For example, a solution of ferric chloride and sodium citrate on being allowed to stand in a stoppered flask lost its original greenish-yellow color after some time. A similar solution which contained manganese did not change color. On testing them the first one showed only a slight test for ferric iron and a strong test for ferrous iron, and the second solution showed just the reverse.

Culture experiments with yeast also indicate that the reduction of the iron by the yeast organism tends to be prevented by the presence of manganese. Further, oxidation-reduction potential measurements on culture solutions containing ferric iron and sodium citrate show that when manganese is added a higher potential is developed.

On this basis it is believed that not only the necessity of manganese but its toxicity can be explained. In the first case, sufficient manganese must be present to insure the reoxidation of the iron after its reduction by the organism. In the second case, a large amount of the element either results in too high a concentration of ferric ions or prevents its reduction by the organism. Different species may be expected to vary in their relation to manganese depending on the reducing power of their cells.

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[5] E. F. Hopkins and F. B. Wann, "Iron Requirement for Chlorella," *Bot. Gaz.*, 84: 407–427, 1927.

[6] *Bot. Gaz.*, 83: 194–201, 1927.

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